The Prediction of China CO_2 Emission in 2015

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Abstract- **The GDP, energy consumption, energy structure and CO_2 emission of China in 2015, are calculated by the use of grey forecasting model based on the twelfth Five-Year (2011-2015) plan for Chinese national economic and social development, the "Twelfth Five-year" work plan to control greenhouse gas emissions and the China energy structure data of "eleventh five-year plan". The conclusion that Chinese per unit of GDP CO_2 emission will be reduced by 17.4% compared with testified in 2010.**

Keywords- GDP; Energy Consumption; Energy Structure; Carbon Dioxide Emission of Per Unit GDP

I INTRODUCTION

Global warming caused by human economic and society activities has threatened human survival, which is a world consensus. United Nations Framework Convention on Climate Change (UNFCCC), which was formulated by United Nations intergovernmental negotiating committee on May, 22nd 1992 about the issue of climate change, passed at Summit Session of UNCED on June, 4th 1992 in Rio de Janeiro, Brazil, and went into effect formally on March, 21st 1994, puts forward common but differentiated responsibilities: "As significant sources of greenhouse gas emissions, developed countries should take concrete measures to limit greenhouse gas emissions and provide developing countries funds to perform convention obligations; developing countries take responsibility to provide the detailed national lists of greenhouse gas source and sink, work out and implement the relevant solutions, and at the same time it is not necessary for developing countries to assume the legally binding duties of reducing GHG." The convention has become a basic framework on curbing worldwide emission of greenhouse gas such as CO_2, responsing to the harmful influence of human economy and society caused by global warming and going on international cooperation about global climate change for international society. The climate-change conference has been held in Geneva, Kyoto, Buenos Aires, Bonn, and Hague, Bali, Poznan, Copenhagen, Cancun, Durban once a year after COP 1, the Berlin conference, March, 28th 1995. Especially in the Kyoto (COP 3) on December, 11th 1997, the representatives of 149 countries and regions passed Kyoto Protocol, which regulated that greenhouse gas emissions of main industrial developed countries would be reduced by 5.2% averagely on 1990 levels from 2008 to 2012, with the European Union cutting 6 kinds of greenhouse gas emissions by 8%, the United States cut 7% and Japan cut 6%. On Indonesia's Bali island conference (COP 13) in December, 2007, countries discussed how to further reduce the greenhouse gas emissions, "post-Kyoto" problem, after the first commitment period of Kyoto Protocol expires in 2012, passed the "Bali Roadmap", launched the negotiating process on strengthening the overall implementation of UNFCCC and Kyoto Protocol to devote to finishing the first commitment period by the end of 2009, arranging new negotiation and signing corresponding agreements for replying global climate change after Kyoto Protocol expires in 2012. The Durban conference in South Africa (COP 17) from November, 28th to December 9th 2011, the last climate conference before the first commitment period of the official document for the United Nations to reply for climate change, the Kyoto Protocol expires in 2012, was aimed to determine that the second commitment period of Kyoto Protocol would begin in 2013, and the participating countries reach a consensus on the new emission reduction goals. Although the Global Recession, various disharmonious voices, even unwise behavior of some countries dropping out of the Convention, the conference finally achieved the aim that emissions reduction targets for advanced countries and the global total emission reduction goals which developing countries should make their corresponding contributions to. The conference stressed that in order to cope with climate change, all the contracting parties should think over their ability, justice, and historical responsibility to make greater contributions in long-term cooperation according to the objectives, principles, and regulations of the Convention and Kyoto Protocol, especially on the basis of the "Common but Differentiated Responsibilities" principle. China, as one of developing countries, also expressed the position "we don't rule out accepting binding emission reductions targets in the future". In fact, China is always a big responsible country on responding to climate change and emission reduction issue. During the five years from 2005 to 2010, China has cut energy consumption per unit of GDP by 19.1%, which is equal to save 630 million tons of standard coal, or 1.5 billion tons of carbon emissions. In addition China has been the first powerful country of carbon emissions reduction in the same period [1]. What is more, Chinese government passed the "twelfth five-year" work plan to control greenhouse gas emissions on November 10th, 2011[2]: actively tackling climate change should be regarded as the important strategy of economic society development and the great opportunities of accelerating transformation of the mode of economic development, restructuring the economy and promoting new industrial revolution:

- utilize various of control measures comprehensively, speed up industrial restructuring, promote energy and resources saving vigorously, develop low-carbon energy positively, increase forest carbon sink energetically; establish low-carbon experimental sites, explore to create carbon emissions trading market;
- speed up the establishment of greenhouse gas emissions statistical accounting system, establish fundamental statistical system, develop accounting guidelines;
- motivate low-carbon & energy saving action of the whole society. State organs, institutions, social organizations and other public institutions should play an exemplary role. Fulfill enterprise responsibility and make clear emission control standards & requirements of key industries and enterprises. Improve public participation awareness and encourage low-carbon green & healthy and civilized lifestyles and consumption patterns vigorously;

- promote international cooperation extensively, strengthen technology and talents support, and focus on development and promotion of economical low-carbon technologies. By 2015, China will achieve the target that CO_2 emission per unit of GDP will be 17% lower compared with 2010. Just as the UN Secretary-General Ban Ki-moon said in Abu Dhabi fifth World Future Energy Summit, "China, as the world's second economic powers, adopts the very wise investment strategy for the future energy. China is not passively waiting for a development framework from international community, but initiatively takes effective action with clear development ideas [3]".

This paper will predict and calculate Chinese greenhouse gas emissions in 2015 based on the evolution of China's energy structure, on the basis of forecasting China's energy demand and total energy structure evolution.

II METHODS

A. China's Economic Development Forecasting Method

As a national strategic intent, the government topmost priority, guide of the behavior of market players, the twelfth Five-Year (2011-2015) plan for China's national economic and social development is the grand blueprint of the next five-year national economic and social development, the common action program of people of all ethnic groups in our country, the important basis of government to fulfill such duties as economic regulation, market supervision, social management and public service. It considers that the world situation and national conditions continue to undergo profound changes, and economic and social development shows new stage characteristics in China during the Twelfth Five-Year Plan time period: put forward the guiding ideology that taking scientific development as the theme and accelerating transformation of the mode of economic development as the main line; to speed up the transformation of the mode of economic development, we should insist on the strategic adjustment of the economic structure as the main target direction, the scientific and technological progress and innovation as the important support, security and improve the livelihood of the people as the fundamental starting point and end point, building a resource-conserving, environment-friendly society as the important focus, reforming and opening up as a powerful driving force, as well as sets the goals that maintain stable and rapid economic development, GDP grows at an annual average of 7%, increasing the proportion of non-fossil fuels in primary energy consumption to 11.4%, energy consumption per unit of GDP is decreased by 16% and CO_2 emission per unit of GDP is reduced by 17% to save resources and protect the environment [4].

Then China's GDP in 2015 can be calculated accordingly by using development index:

$$\begin{aligned} GDP_{2015} &= GDP_{2010}(1+7\%)^5 \\ &= 39.8\times 1.07^5 = 55.8(\text{trillion yuan}) \end{aligned} \tag{1}$$

According to Statistical Review of World Energy published by B.P [5], we can obtain the data of China's energy structure and total energy consumption in 2010 as shown in Table Ⅰ.

TableI TCHINA'S ENERGY CONSUMPTION AND ENERGY STRUCTURE STATISTICS

	Energy Consumption	Coal	Oil	Natural Gas	Renewable Energy
	Ten Thousand Tons of Oil Equivalent	*%*	*%*	*%*	*%*
2006	181073.2	71.1	19.3	2.9	6.7
2007	196355.6	71.1	18.8	3.3	6.8
2008	204013.6	70.3	18.3	3.7	7.7
2009	214652.9	70.4	17.9	3.9	7.8
2010	227500.0	70.0	17.6	4.0	8.4

Therefore, in 2010, China's energy consumption per unit of GDP is: 32.5÷39.8=0.82 (tons of standard coal/ten thousand yuan GDP); carbon dioxide emissions per unit of GDP is: 70.79÷39.8=1.7786 (tons of CO_2/ten thousand yuan GDP) (GDP of 2010 is 39.8 trillion yuan [6]).

B. China's Energy Structure Evolution Forecasting Method

To predict China's greenhouse gas emissions in 2015, it is necessary to investigate its energy consumption and energy structure. The data of China's total energy consumption and energy structure [5] from 2006 to 2010 is shown in Table Ⅰ.

The Chinese government's Twelfth Five-year Work Plan to control greenhouse gas emissions puts forward that, develop low-carbon energy positively, adjust & optimize the energy structure, promote clean use of coal, encourage development and utilization of coal bed methane and natural gas, develop nuclear power on the basis of ensuring safety, develop hydropower vigorously under the premise of good ecological protection and resettlement of immigrants, vigorously develop non-fossil energy sources such as wind power, solar, biomass, geothermal and so on according to local conditions to promote the popularization and application of the distributed energy system [2].

To analyze the evolution of China's energy structure, there are many forecasting methods based on a large size data sample for example statistic trend, regression analysis, Markov model and minimum variance forecasting etc. However, for the consistency of statistical data, and the energy structure presenting a significant change only in the last few years, this paper uses gray prediction model[7] GM (1,1) based on a few data in the eleventh five-year plan period.

1) Definition of GM (1, 1):

Define $x^{(0)}$ as the modeling sequence of GM (1, 1):

$$x^{(0)} = \left(x^{(0)}(1), x^{(0)}(2), \cdots, x^{(0)}(n)\right) \tag{2}$$

Define $x^{(1)}$ as the AGO sequence of $x^{(0)}$:

$$\begin{aligned} x^{(1)} &= \left(x^{(1)}(1), x^{(1)}(2), \cdots, x^{(1)}(n)\right) \\ x^{(1)}(1) &= x^{(0)}(1) \\ x^{(1)}(k) &= \sum_{i=1}^{k} x^{(0)}(i) \end{aligned} \tag{3}$$

Define $z^{(1)}$ as the mean sequence of $x^{(1)}$:

$$\begin{aligned} z^{(1)}(k) &= 0.5x^{(1)}(k) + 0.5x^{(1)}(k-1) \\ z^{(1)} &= \left(z^{(1)}(2), z^{(1)}(3), \cdots, z^{(1)}(n)\right) \end{aligned} \tag{4}$$

Then the grey differential equation mode's definition of

GM (1, 1) is:

$$x^{(0)}(k)+az^{(1)}(k)=b \tag{5}$$

2) Mechanism of GM (1, 1) Model:

Mechanism of GM (1, 1) model is shown in Figure 1.

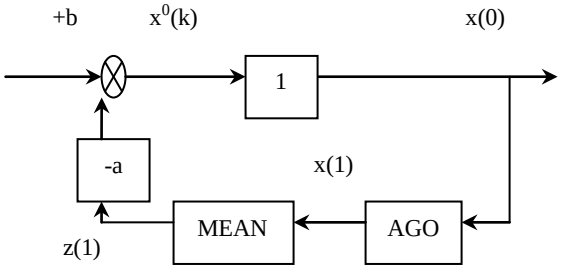

Fig. 1 GM (1,1) frame chart

3) GM (1, 1) Matrix Equations and Parameter Identification:

When k = 2, 3, ..., n, formula (4) is:

$$x^{(0)}(2)+az^{(1)}(2)=b$$
$$x^{(0)}(3)+az^{(1)}(3)=b$$
$$\vdots$$
$$x^{(0)}(n)+az^{(1)}(n)=b$$

Define: $y_N=\left(x^{(0)}(2),x^{(0)}(3),\cdots,x^{(0)}(n)\right)^T$

$$B=\begin{pmatrix}-z^{(1)}(2) & 1\\ -z^{(1)}(3) & 1\\ \vdots & \\ -z^{(1)}(n) & 1\end{pmatrix} \tag{6}$$

$$p=\begin{pmatrix}a\\ b\end{pmatrix}$$

Then: $y_N=BP$

Under the ordinary least squares criterion:

$$P=\left(B^TB\right)^{-1}B^Ty_N$$

4) GM (1, 1) Forecast:

After getting a, b, GM (1, 1) prediction model is:

$$\hat{x}^{(1)}(k+1)=\left[x^{(0)}(1)-\frac{b}{a}\right]e^{-ak}+\frac{b}{a} \tag{7}$$
$$\hat{x}^{(0)}(k+1)=\hat{x}^{(1)}(k+1)-\hat{x}^{(1)}(k)$$

III RESULTS

A. China's Energy Structure in 2015

The prerequisite [8] to use of GM (1, 1) is that the sequence level as formula (1) must be satisfied the condition showed as expression (7):

$$\sigma(k)=\frac{x^{(0)}(k-1)}{x^0(k)}\in[0.1353,7.389] \tag{8}$$

The proportions of coal, oil, natural gas, and renewable energy in total energy shown in Table Ⅰ all meet the GM (1, 1) conditions of usage. Then China's energy structure in 2015 as shown in Table Ⅱ can be calculated using GM (1, 1) based on the data of Table Ⅰ.

TableII THE PREDICTION OF CHINA ENERGY STRUCTURE FROM 2011 TO 2015

Year	Coal	Oil	Gas	Renewable Energy
	%	%	%	%
2011	69.6	17.2	4.3	9.0
2012	69.3	16.8	4.5	9.4
2013	68.8	16.5	4.7	10.0
2014	68.3	16.1	5.0	10.5
2015	67.8	15.8	5.2	11.1

B. China's CO_2 Emission in 2015

In accordance with Chinese government's goal that energy consumption per unit of GDP is decreased by 16% in 2015, the total energy consumption is 3.827 billion tons of standard coal on the occasion. Based on 2015 energy structure in Table Ⅱ, and energy calorific value: 1 t.c.e = 0.7 tons of oil equivalent = 700 cubic meters of natural gas, this paper calculates and gets China's energy constitute in 2015 as Table 3 shows; besides according to the fact that consuming 1 t.c.e emits 2.78 tons of CO_2, consuming one ton of oil discharges 1.85 tons and consuming 1,000 cubic meters of natural gas emits 1.49 tons, China's CO_2 emission in 2015 is shown in TableⅢ.

TableIII CALCULATION OF CHINA CO_2 EMISSION IN 2015

	Coal	Oil	Gas	Ren.	Total
Ratio	67.8	15.8	5.2	11.1	100
Quantity	25.99	4.23	1.39	4.25	38.27
Unit	10^8t.c.e	10^8t.o.e	$10^{11}m^3$	10^8t.c.e	10^8t.c.e
CO_2	72.3	7.8	2.1	0.0	82.2
Unit	10^8ton	10^8ton	10^8ton	10^8ton	10^8ton

According to TableⅢ, China's CO_2 emission per unit of GDP is 1.47 t/ ten thousand yuan GDP, decreased by 17.4% compared with 2010 (1.78 t / ten thousand yuan GDP).

IV DISCUSSION AND CONCLUSION

In Abu Dhabi fifth World Future Energy Summit, the UN Secretary-General Ban Ki-moon said, "As the world's second largest economy country, China adopts the very wise investment strategy for the future energy. China is not passively waiting for a development framework from international community, but initiatively takes effective action." Chinese government's energy and emission reduction goals must be realized because of the solid material foundation. Only the change of China's energy structure is sufficient to prove this point. By 2015, China will build a competitive industrial system of renewable energy, the total development amount of wind power, solar, biomass energy, solar thermal utilization and nuclear power and other non-fossil energy will reach 480 million tons of standard coal, with wind power 100 million kilowatts, solar power 15 million kilowatts; rich coal bed methane, conventional natural gas and shale gas resources also provide strong guarantee for China's clean energy development, as well as provide a solid foundation to achieve the government planning goal of 30 billion cubic meters of CBM production and 260 billion cubic meters of natural gas. In conclusion, China has the ability that "we don't rule out accepting binding emission reductions targets in the future".

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